Characterizing Magnetostriction in FePtPd Thin Films

Abstract: This collaborative work focuses on magnetostriction properties in $L1_0$ ordered $Fe_{50}Pt_{(50-x)}Pd_x$ thin films of varying Pd content, x. In our earlier collaboration, the range of film compositions prepared was limited but suggested that magnetostriction was composition dependent and could hence be tailored by controlling the film composition. Accordingly, additional samples were sputter-deposited and their magnetostriction properties were characterized via the cantilever bending technique. Simultaneously, the crystalline structure and the magnetic anisotropy were verified by X-ray diffraction and SQUID magnetometry, respectively. Measurements and analyses are ongoing and expected to yield a deeper insight to the composition dependence of magnetostriction in these films.

FePtPd alloy films, with strong perpendicular magnetic anisotropy, are leading candidates for recording media in next-generation hard disk drives and solid state multiferroic random access memory technologies. The magnetostrictive properties of such materials are of importance, as strain can be used to manipulate their magnetic anisotropy and therefore their magnetic switching characteristics. It is known that the perpendicular anisotropy of $L1_0$ ordered FePtPd alloys increases as the Pt content is increased. Our research goal is to identify if magnetostriction follows a similar trend or has a maximum at intermediate composition.

The 100 nm thick $Fe_{50}Pt_{(50-x)}Pd_x$ films were deposited directly on 0.3 mm thick single crystal MgO (100) substrates. The films were prepared by co-sputtering from three independent targets. The sputtering input power to the Pd and Pt targets was adjusted to obtain films with a desired Pd content, x, spanning from 0 to 50 atomic percent. FePt (x=0) and FePd (x=50) samples were also deposited at different substrate temperatures to examine the effect of temperature-driven ordering on the anisotropy and magnetostriction. $L1_0$ ordering was confirmed by X-ray diffraction measurements.

The in-plane and out-of-plane hysteresis loops of the samples were measured by SQUID magnetometry to confirm the desired strong perpendicular magnetic anisotropy.

The magnetostriction of the samples was determined using the cantilever bending method implemented on the physical properties measurement system (PPMS) available at IMR, Tohoku University, using a custom substrate clamping fixture, displacement sensor and control software. An in-plane magnetic field varying from -9 T to 9 T and back was applied along the cantilevered MgO substrate (with the FePtPd film on the bottom surface) and the deflection of the free end of the cantilever, resulting from the expansion or contraction of the film via the magnetostrictive effect, measured. The displacement as a function of the magnetic field is shown in Fig. 1 and

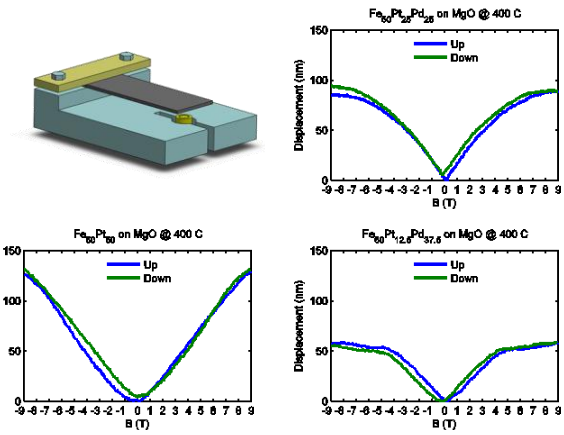

Fig. 1 Illustration of the cantilever bending method for magnetostriction measurement and resulting cantilever displacements plotted as a function of the applied field for samples of different Pd content, x.

can be used to determine the magnetostriction. As can be seen from these example data, there is hysteresis (due to misalignment of field direction with respect to sample plane) and sometimes lack of a significant saturation (flat) region, which has impaired conclusive analysis of these measurements. We are anticipating delivery of a 14 T PPMS at Oregon State University in September 2016; and expect to continue the measurements towards the completion of this study.

We plan a publication [1] upon the acquisition of conclusive results.

References

[1] S. Kikushima, W. Zhou, P. Lenox, T. Seki, K. Takanashi, A. Jander, and P. Dhagat, "Magnetostriction Measurements of L10 $Fe_{50}Pt_{(50-x)}Pd_x$ Thin Films", (unpublished).

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